Population dynamics and elephant movements within the Associated Private Nature Reserves and adjoining Kruger National Park

SAVE THE ELEPHANTS

ELEPHANT RESEARCH

–A·P·N·R–

Progress Report
November 2004

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Elephant Research, APNR

1. <u>Introduction</u>

This report covers the period December 2003 to November 2004. It essentially provides a review of the first year of the study.

Michelle Henley (Ph.D.) (*née* Greyling) has been running the research programme since June 2003. In May 2004 Steve Henley (Ph.D.) joined the project on a full-time basis to assist.

The objectives of the programme are:

1) To determine how many elephant bulls use the APNR.
2) To determine how many breeding herds frequent the APNR.
3) To identify the big tuskers that frequent the APNR.
4) To determine the movements of elephants within the APNR and adjacent areas. As these reserves are linked with the KNP and other Trans-frontier Reserves in Mozambique and Zimbabwe, the study can potentially provide information on the movements of elephants at a meta-population level.
5) To determine the changes in the density of elephants within the APNR and how this changes over time and whether these changes are through births, deaths or elephant movements to and from the KNP.
6) To establish the extent to which elephants frequent different parts of the APNR and KNP.
7) To determine whether food resources and/or social and safety benefits motivate elephant movements.
8) To quantify the impact of elephants on specific tree species.

2. <u>Results</u>

2.1. *Elephant identification*
A total of 668 bull sightings have been made from May 2003 until November 2004. The identification kits of 326 individual bulls were collected during the study period. A third order polynomial model was used to describe the relationship between the cumulative number of individual sightings over time (Fig. 1; $r^2 = 0.994$) and the rate at which elephant bulls are re-sighted ($r^2 = 0.996$). When multiple sightings of an individual are pooled within a month, only 32% of all bull sightings could be considered to be re-sightings. However, the daily re-sighting rate of known individuals is approximately 49%.

A total of 139 sightings of distinct family units were made during this study. Sightings of family units have focussed on collecting identikits of adult cows within the family unit of which a total of 98 identikits have been collected from 19 distinct family units. Bulls have been associating with family units in 21% of all bull sightings.

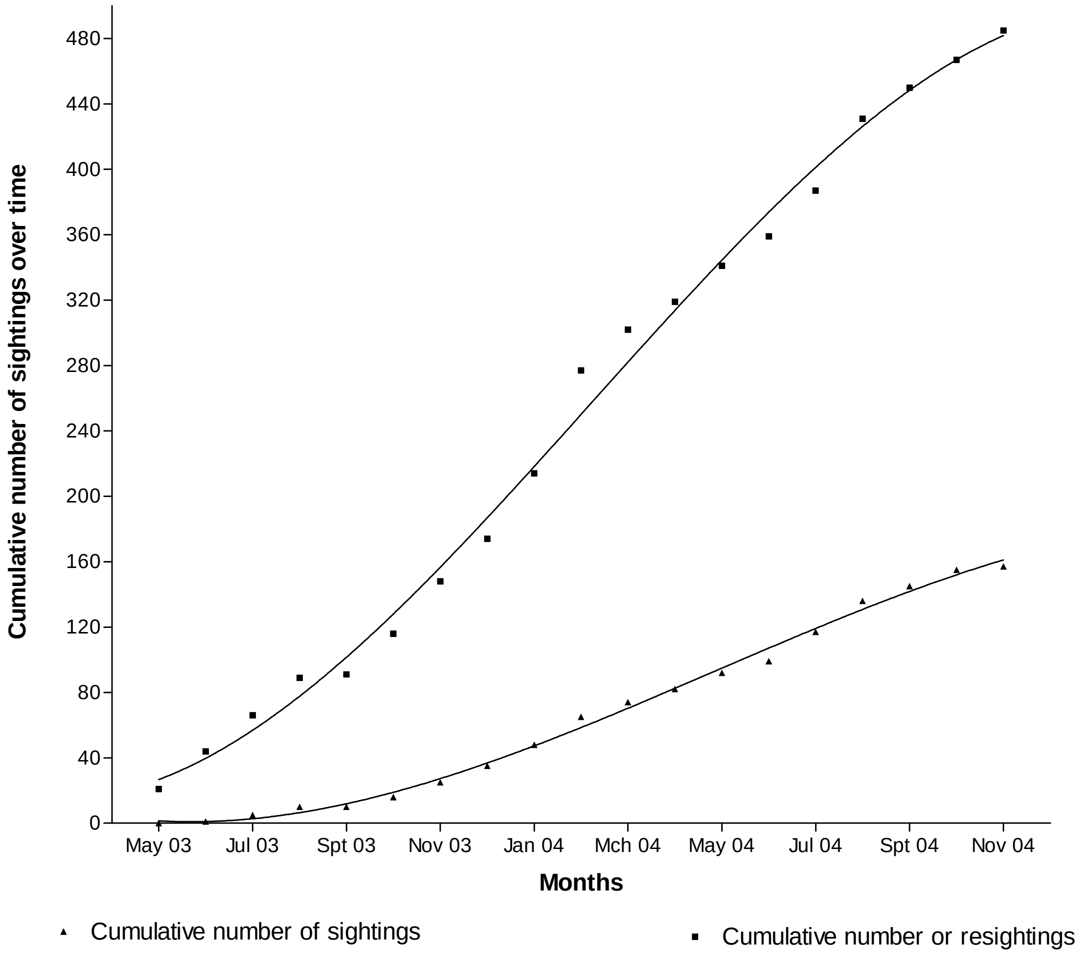

Fig.1. The cumulative number of sightings and re-sightings of bulls from May 2003 until November 2004.

In general the monthly proportion of musth bulls followed the rainfall cycle closely. The data collected during the initial study period (May – September 2003) can in this instance, be largely ignored as the proportion of musth bulls collected during this time would be influenced by the number of bull identikits collected at the outset of the study. Furthermore, September 2003 does not reflect the number of musth bulls present as travels abroad led to limited fieldwork being conducted during this month. The proportion of musth bulls reached a peak from March through to May 2004 (Fig. 2). This period would be the most suitable time for bulls to come into musth as it follows a two-month time lag in a peak in the mean monthly rainfall. Cows impregnated from March through to May would give birth 22 months later from January through to March during the late rainy season. By implication, these cows would have access to the most nutritious food sources when their physiological needs would be the highest such as during late pregnancy and early lactation. Their offspring would consequently have the greatest chance of survival. It is interesting to note that 38% of bulls in musth from March through to May could be considered large tusked individuals which include both Classic and Mac. Only 23% of the bulls in musth at other times of the year could be considered large tusked individuals (tusks in excess of 80lbs).

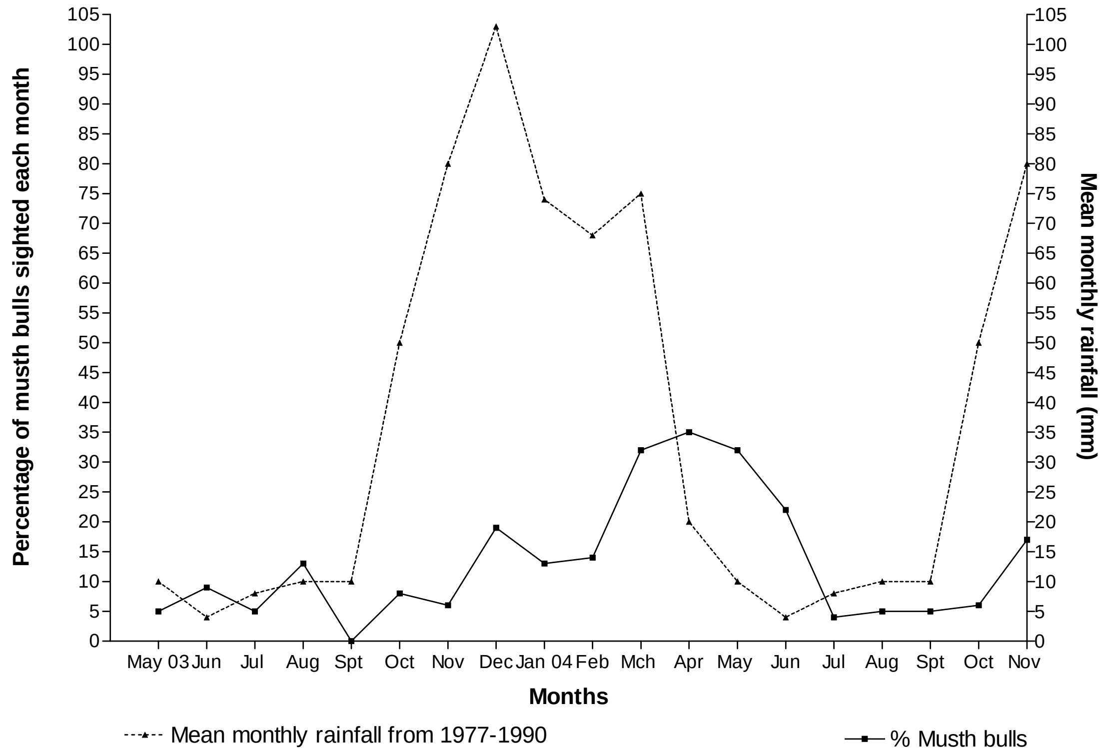

Fig. 2. The proportion of musth bulls expressed as a percentage of the total number of bulls sighted within each month from May 2003 until November 2004.

Most sections of the APNR have been traversed in search of elephants. Our travels have also included two trips to Kruger National Park to locate Mac as well as a trip to Phalaborwa Mining Co. to locate a recently collared cow when she moved outside of the APNR. The figure below does not reflect all the tracks that were traversed due to overlap in certain sections and only shows the tracks collected since October 2003 as traversed areas were not recorded prior to this. Identikits were also collected in sections with no tracks as a few strategic people have become actively involved in the collection of identikits. We are very grateful to Cathy Greyling (Ingwelala), Chris Hall (Timbavati Technicon student), Rudi Goerke (Klaserie), Les Penfold (Ingwelala) and Gustav Roux (Klaserie) for their assistance and participation.

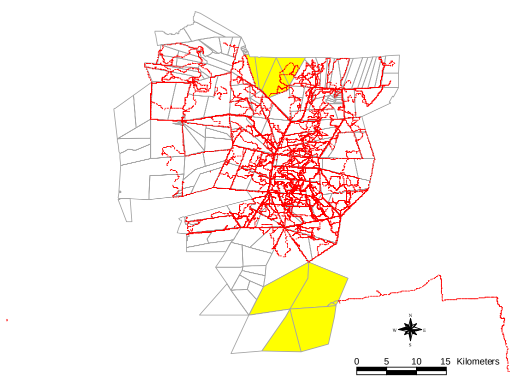

Fig. 3. Field work routes covered. Yellow sections of the map are areas in which traversing is prohibited.

2.2. *Telemetry study*

Five new GPS-satellite collars were placed on elephants this year. A bull, Classic Charlie, and a cow, Diney, were fitted with collars in May. Two more bulls, Benjamin and Alex, and a cow, Joan, were collared in November. Mac, who was initially collared in May 2002, and had his collar replaced in August 2003, is still providing data. Consequently, there are six satellite collared elephants being monitored as part of the study: three mature bulls, one young adult male (Alex) and two adult cows. Telemetry data has now been gathered for a 2½ year period, however most data cover a more limited period (cf Table 1).

Table 1. A summary of telemetry data for the six monitored elephants. The remaining lifespan of the collars is based on the assumption that the batteries will provide sufficient power for *ca* 1 500 data points.

	Period:		Data set: localities recorded	remaining
Mac	May 2002 →	30 months	2 330	280
Classic C.	May 2004 →	6 months	550	950
Benjamin	Nov 2004 →	1 month	80	1 420
Alex	Nov 2004 →	1 month	60	1 440
Diney	May 2004 →	6 months	530	970
Joan	Nov 2004 →	1 month	80	1 420

To date the telemetry data has been collected with an eight hour sampling interval (*i.e.* three recorded plots per animal per day - early morning, early afternoon and evening). An exception being Mac, who's timetable was changed earlier this month to once per day (early morning). This was done during his non-musth period, spent in the Kruger NP, to ensure that the collar will still be functioning when he is expected return to the APNR in May 2005 (*ca.* 180 days time). We are currently in the process of reviewing the schedule of the other collars in an attempt to maximise their lifespan, thereby reducing the impact of collaring on study animals and the cost of replacement, while ensuring that appropriate data are collected to address the objectives of this study and the requirements of statistical analyses (see Appendix 1). Changes will only be made after consultation with the collar manufacturer - to ensure feasibility - and the scientific advisor to the project, Dr. Iain Douglas-Hamilton – to ensure desirability.

At this point in the study only Mac has provided data that cover a sufficient period of time for the effective evaluation of home range. However, Classic Charlie and Diney's data span a period of time that provides some useful indications of range use patterns (Fig. 4).

Mac's home range size, calculated as the minimum convex polygon (MCP), is 5 090 km^2. The inclusion of this year's data has increased the size of his estimated home range (4 540 km^2 – November 2003) by 12%. Given the extreme sensitivity of the MCP method to data points on the periphery of the range, the results imply that Mac has essentially remained within the same area.

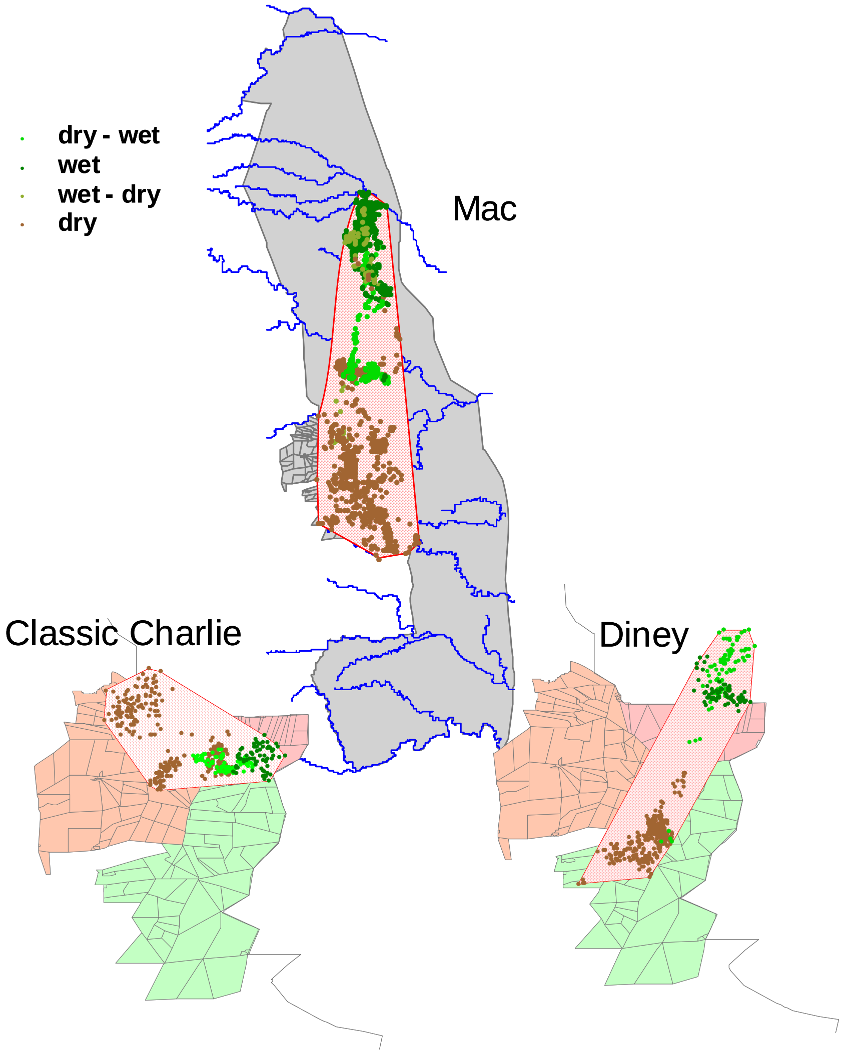

Fig.4. Home range of three collared elephants within the APNR and KNP as determined by the minimum convex polygon. Location points are coloured coded according to season.

Among the few merits of the MCP method of home range estimation are its simplicity and the fact that it has been used by wildlife ecologists for a relatively long period of time. These attributes facilitate comparison between studies. Mac's home range is substantially larger than the 238 km^2 (range: 78-342 km^2) that was previously calculated to be the mean home range size of elephant bulls in the Kalserie and Timbavati PNRs (de Villiers & Kok 1997). This earlier study was done prior to the removal of fences between the APNR and the KNP, and as such the opportunity for large scale movements, such as that of Mac, was limited. This serves to highlight the fact that for many studies elephant home range estimation may be as much a function of the size of the conservation area as it is of the behaviour of the elephants themselves. Mac's home range is also substantially larger than the average range for other bulls recorded in semi-arid savanna ecosystems, and is similar to that of elephants from desert regions (cf. Table 2).

Table 2. Elephant home range size estimates

Area (km^2)	Sex	Location	Source
1 7740† (11500-23 980)	male and female	Mali	Steinberg 2003
6 436† (2 136-10 736)	male	Namibia	Lindeque & Lindeque 1991
5 090	male - Mac	APNR	this study
2 815† (102-5 527)	female	Laikipia-Samburu area, Kenya	Thouless 1993
2 775† (2 484-3 066)	female	northern Cameroon	Tchamba *et al.* 1995
2 459† (1 973-2 944)		Kaokoveld, Namibia	Viljoen 1989
1 878† (447-3 309)	female	northern Botswana	Verlinden & Gravor 1998
1 800	female	Tsavo East - semi-arid	Owen-Smith 1988
1 660† (785-2 534)		Waza NP, Cameroon	Tchamba *et al.* 1994
1 600		Tsavo East	Leuthold 1977
1597		Mago NP, Ethiopia	Demeke & Bekele 2000
880	male and female	Congo & CAR	Blake *et al.* 2001
750		Tsavo West	Leuthold 1977
414	female	Timbavati PNR	deVilliers 1994
408		Tsavo West - mesic	Owen-Smith 1988
263		Zambezi Valley - mesic	Dunham 1988
238	male	Kalserie and Timbavati PNRs	deVilliers 1994
230		south-west Cameroon - wet forests	Powell 1997
290† (115-465)	female	APNR	DeVilliers & Kok 1997
183	female	Klaserie PNR	deVilliers 1994
100	male	Pilanesberg NP	Slotow & van Dyk 2002
33† (14-52)		Lake Manyara, Tanzania - ground water forest	Owen-Smith 1988

† - median, calculated from the published range of values given in parentheses

It would seem however, that Mac's large home range is not necessarily the norm for this area. Based on their limited data sets, Classic Charlie and Diney's home ranges (MCP) are 385 km^2 and 482 km^2 respectively. While these estimates are based on less than a full year's data, for the animals to change their range so that it is of a similar magnitude as that of Mac would mean a substantial shift in range area within a relatively short period, particularly as Classic Charlie's estimated range already includes musth and non-musth areas. Classic Charlie and Diney's partial home range sizes are more consistent with other published range estimates from similar environments (cf. Table 2).

The variation in range size between Mac and Classic Charlie, and the fact that Diney's range size is intermediate between that of the two bulls, suggest that there would be no significant difference in the size of male and female ranges.

At this time there is insufficient data to justify calculating the MCP home range of Benjamin, Alex and Joan.

Patterns of range use are better evaluated using a grid-cell approach or parametric-probablistic range models. Mac, Classic Charlie and Diney's range size based on the 95% probability plot using a Kernel estimation are 6 614 km^2, 484 km^2 and 540 km^2 respectively (Fig. 5).

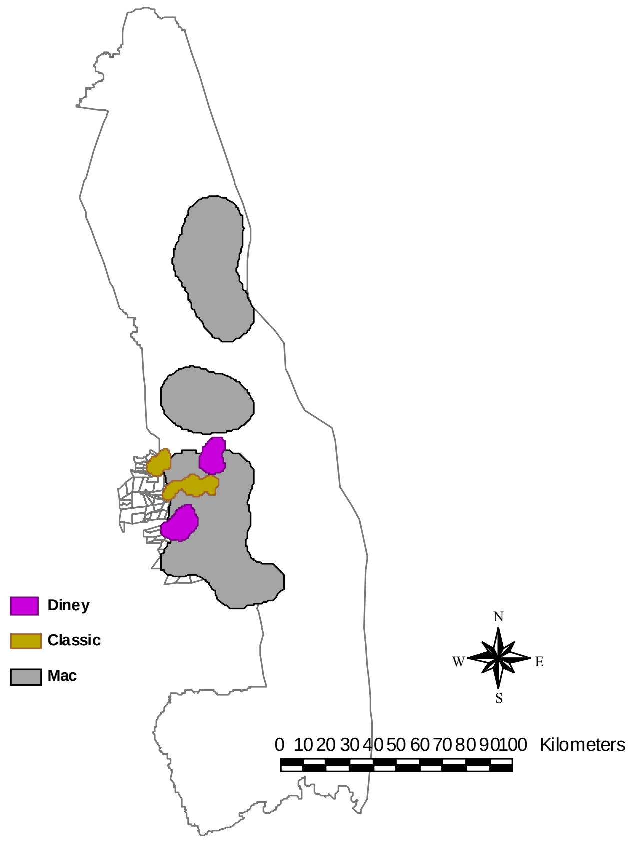

Fig. 5. Elephant home range as determined by Kernel derived the 95% probability isolines.

Both Mac and Classic Charlie's range nodes define areas utilised separately during musth and non-musth periods. Mac's musth range is the southern node and Classic Charlie's the north-western node. Classic Charlie's standardised rate of movement (km/h) (Fig. 6) during the period that he was observed to be in musth and in the north-west differed highly significantly from that when he was out of musth and in the south-eastern portion of his range (p =< 0.001; t = 8.84; df = 180). His mean rate of movement was higher within the musth range, $\bar{x}$ = 0.16 km/h (SE = 0.02), than the non-musth range, $\bar{x}$ = 0.04 km/h (SE = 0.004). Once sufficient data have been gathered, rate of movement and turning angle may serve as useful indicators of musth and non-musth ranges in bulls.

Mean rate of movement varies between the individual elephants. For the same period (25 May to 23 November 2004) Mac, Classic and Diney all had rates of movement that were significantly different (Mann-Whitney U-test p < 0.01). These difference are not related to sex (Mac $\bar{x}$ = 0.115 km/h; Diney $\bar{x}$ = 0.091 km/h; Classic $\bar{x}$ = 0.086 km/h).

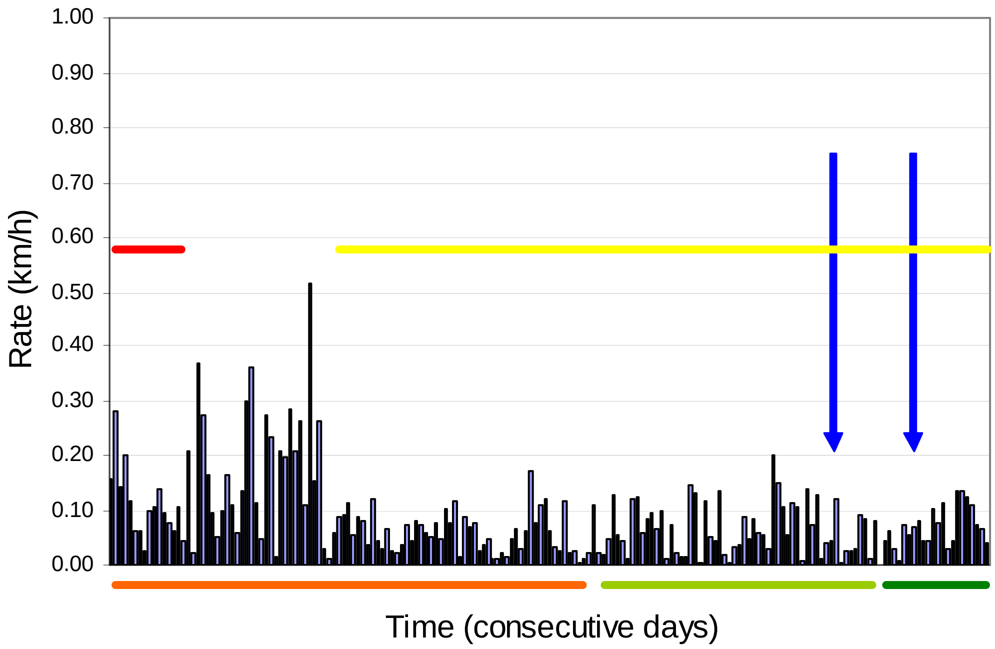

Fig. 6. A sequential plot of Classic Charlie's daily rate of movement. The red and yellow lines highlight the period when Classic was observed to be in musth and not in musth repectively. The blue arrows point out the first substantial rainfall events (>20mm) of the 2004/2005 austral year. The brown line along the x-axis (abscissa) defines the dry season, the olive line the dry-wet transition period and the green line the wet season.

Fig. 5 also clearly shows how Classic and Diney's ranges intersect but don't overlap. Diney shows two distinct nodes in her pattern of range use, one south of Classic's non-musth range and the other north of this area. A sequential plot of her daily rate of movement shows a spike in movement patterns (Fig. 7, highlighted with the red arrow), this corresponds with her rapid movement from the southern node to the northern. At this stage it is not clear as to why she moves so rapidly through what is for Classic a "bull retirement area".

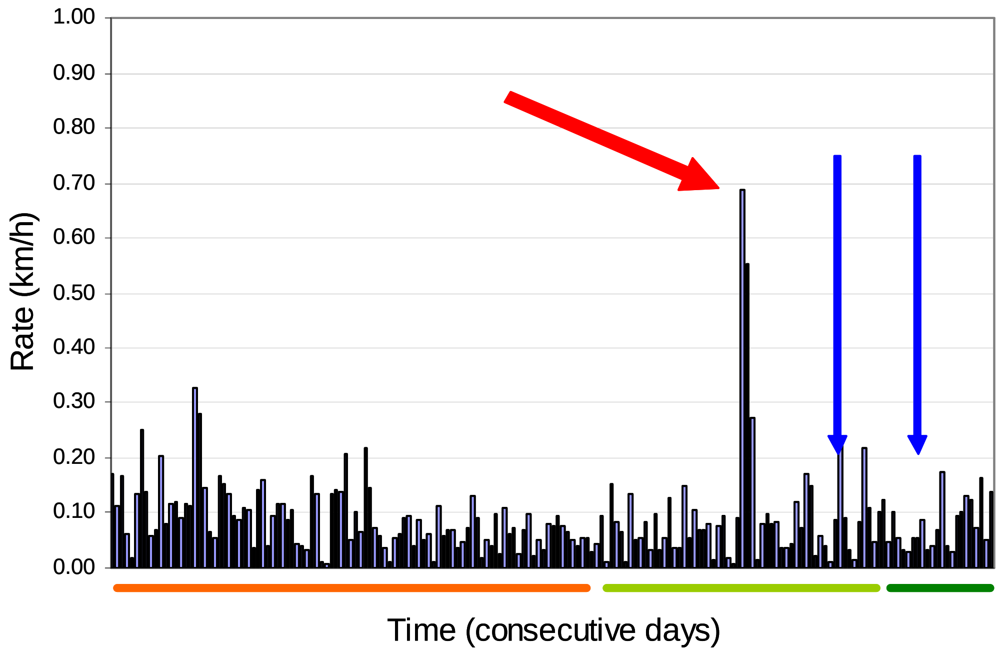

Fig. 7. A sequential plot of Diney's daily rate of movement. The blue arrows point out the first substantial rainfall events (>20mm) of the 2004/2005 austral year. The brown line along the x-axis (abscissa) defines the dry season, the olive line the dry-wet transition period and the green line the wet season. The red arrow highlights the period when she moved from the southern portion of her range to the north.

Mac showed a similar rapid increase in rate of movement when he moved from his musth area in the south to the central node in his range between the 29th of July and 2nd of August this year (Fig. 8, highlighted by the red arrow)

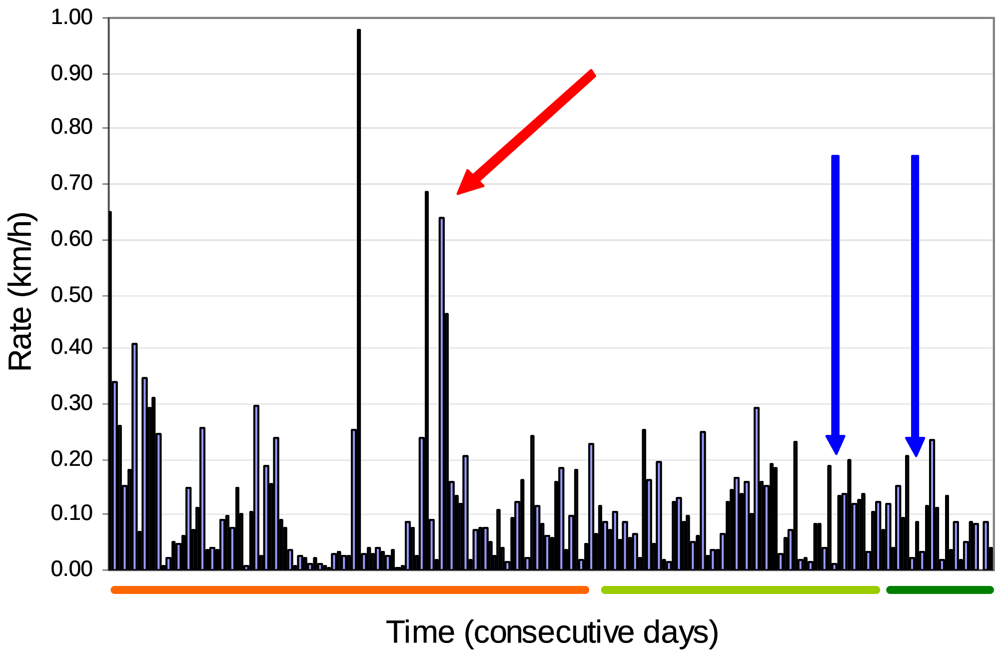

Fig. 8. A sequential plot of Mac's daily rate of movement for the period 25 May to 23 November 2004. The blue arrows point out the first substantial rainfall events (>20mm) of the 2004/2005 austral year. The brown line along the x-axis (abscissa) defines the dry season, the olive line the dry-wet transition period and the green line the wet season.

These patterns infer that there is a strong social influence upon elephant movement patterns. Fig. 4 also suggests that there is a strong seasonal influence associated with the distribution of the collared elephants. Seasons have been defined according to the mean monthly rainfall and temperature conditions (see Appendix 2) such that the dry season covers the months of May to September; October is the wet – dry transitional period; the wet season is November to March; and April is the wet-dry transitional period. This serves as a benchmark against which each month and year can be put into perspective.

Mac's rate of movement in the dry season is significantly greater than that of the wet season ($p = 0.016$; Mann-Whitney $U = 71740$). He also has a highly significant drop in rate of movement between the dry and dry-wet transitional periods ($p < 0.001$; $U = 48660$). At this stage Classic and Diney show no seasonal difference in rate of movement, however their data are still limited and only covers part of the wet season and none of the wet-dry transition period.

An initial evaluation of the data suggests that the distribution of the collared elephants has a clear spatial pattern. This pattern may be determined by social benefits (driven by musth status in bulls) and environmental conditions. Movement patterns also appear to respond to seasonal and social conditions. In the next year specific effort will be focused on 1) landscape scale spatially explicit habitat quality models based on phytosociological data (the recently completed vegetation map for the APNR), rainfall and water availability; 2) daily activity patterns and environmental correlates to put temporal data into behavioural context; 3) musth cycles of collared bulls and 4) associations of the collared animals, particularly the bulls.

2.3. *Vegetation impact study*

As part of an experimental trial to evaluate the effectiveness of wire netting as a means of protecting trees from elephant damage, an area of approximately 12.5 ha was surveyed on the Vlakgesight property. The location, size and damage status of all marulas (*Sclerocarya birrea*) within this area was recorded and then a sample of the population was treated with wire netting. A similar trial has also been initiated at Ntsiri. These trees will be monitored on a regular basis to determine whether the wire netting is effective in preventing elephant damage, and if so what type of damage.

As part of a pilot study, to evaluate the influence of artificial water points on elephant damage to trees, data were collected on the occurrence, size and herbivore impact on marulas and knobthorns (*Acacia. nigrescens*) at four locations in the TandaTula, Vlakgesicht (Hancock), Vlakgesicht (Hair) and Ntsiri. The initial findings were summarised in the August progress report of this year.

2.4. *Mortality study*
Four mortalities were recorded in APNR this year, in addition to those animals shot as a legitimate lethal hunt. Two were adult males and two unsexed juveniles (one of which was possibly a male).

This number of mortalities is comparable with that recorded annually in the recent past (Table 3). Linear regression analysis shows that the population size only accounts for 35% of the variation in the mortality numbers ($p = 0.035$; $r^2 = 0.346$). It may be argued that mortalities are as much a function of rainfall as they are of population size. A multiple regression reveals that together the previous season's rainfall and the same year's elephant population size account for 40% of the variation in annual mortality numbers ($p = 0.08$; $r^2 = 0.4$). Alternatively, the low numbers of animals dying may in itself explain much of the variation from year to year. If a single mortality were missed this year, the number would change by 25%. The variation inherent in small samples may create so much noise in the data set that it is not possible to establish clear associations.

Fig. 3. Natural elephant mortalities and estimated population size as record annually within the APNR.

Year	Population estimate	Mortalities	Mortality rate
1992	**542**	**4**	0.74
1993	**441**	**0**	0.00
1994	**525**	**2**	0.38
1995	**561**	**3**	0.53
1996	**368**	**2**	0.54
1997	**811**	**4**	0.49
1998	**649**	**5**	0.77
1999	**639**	**4**	0.63
2000	**746**	**2**	0.27

2001	**851**	**1**	0.12
2002	**952**	**4**	0.42
2003	**1118**	**7**	0.63
2004	**743**	**4**	0.54

The persistent mortality rate of <1% recorded within the APNR over the past 13 years is substantially lower than the 3.2% estimated by Whyte (2001) in the KNP.

2.5. *Admin/Miscellaneous*

An important aspect of this research programme is the dissemination of insights gained and the stimulation of an interest in elephant ecology and conservation. In the past year 14 presentations were given to APNR Reserve Management Committee meetings, landowners, Shareblock owners and Lodge Managers. A further 40 presentations were given to 162 guests at Tanda Tula, Bateleurs Camp (Andreas Liebenberg), Umlani and Kings Camp in the past 7 months (when we started keeping records).

Michelle was invited to participate in three forums dealing with the issue of elephant culling. One arranged by WESSA, another by IUCN-SA and ESSA, and the third by SANParks. Also arising from these was an interview on Radio Sonder Grense.

By December 2004 four newsletters would have been distributed to more than 600 people which included the wardens, landowners, lodge managers, share block owners of the APNR and other interested parties such as potential sponsors. The newsletters are used to generate interest in the project, to encourage donations, to acknowledge sponsorships and to set up a communication base with all relevant parties. Questionnaires were also distributed to the wardens, landowners, lodge managers and share block owners. The questionnaires were primarily used to identify specific woody plant species which would be monitored for elephant impact based on the concerns raised by landowners.

Two overseas post-graduate students, Alison Foster (Australia) and Paul Roberts (UK) participated in the research programme as volunteers. They were with us for two and three months respectively.

The International Wildlife Health Institute has agreed to assist the Elephant Research Programme with future collaring operations.

4. <u>Conclusion</u>

At this point in time, with the limited data sets, much of the data analyses are exploratory and subjective. With time the resighting rate of known individuals will increase and the telemetry data will cover an entire year for more than one study animal. We expect that from mid-year next year we will be in a position to start performing more rigorous analyses of elephant movement patterns, associations and habitat selection within the APNR and adjacent KNP.

Nonetheless, substantial progress towards meeting the objectives of this research programme has been made in the past year.

Acknowledgements

We would like to acknowledge the wardens, Scott Ronaldson and Colin Rowles, for their logistic support of the project. Save The Elephants and David and Marlene McCay from Tanda Tula Safari Camp are thanked for their financial support of the project. Giles King and other staff members at Tanda Tula Safari Camp are thanked for their logistic support. A very special word of thanks to Mandy Alting for keeping the books of the Elephant Research Programme.

The veterinarians Cobus Raath, Douw Grobler, Peter Rodgers and JJ van Altena are thanked for the participation in the collaring events. Joel Hancock is thanked for supplying the permits for the collaring operations and for assessing the procedures. Tim Paxton is thanked for kindly granting us permission and accompanying us to the collared cow on PMC property the day after the collaring operation.

The following people are thanked for their financial support:
Andreas Liebenberg; Brian & Claire Makare; Charlie Irish; Gordon & Mary Jones; Harry Gazendam from Toyota, Ingwelala Shareblock; Joe Brady; Lonnie Strickland; Malcolm Yorston; Margery Ord; Mr. Schoettle; Nick & Timothy Hancock; Ntsiri Shareblock; Peter Smelting; Stefan Bruer; Tony McClellan and Wayne & Deborah Stokes.

We appreciate all the photographs and ear patterns collected from the following people:
Andrew & Mette Rossaak; Cathy Greyling; Chris Hall; Colin Rowles, Dale Jackson; Frankie Berndt; Gustav Roux; George Piel; Hannes Zowitsky; Joe Brady; John & Keeley Clack; John Nicholson; Keith Jenkins; Les Penfold; Martin Stone; Neil Malan; Patrick O' Brian; Rodney Topham; Rudi Goerke; Sidney Rebe; Stefan Bruer; Theresa McDonald and Yuval Erlich.

Alison Foster and Paul Roberts are thanked for their work as volunteers.

Last but not least, we would like to thank all the landowners of the APNR for allowing us to traverse their property and study the elephants. Without their support, this project would not be possible.

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Appendix 1

Proposed sampling telemetry sampling schedule

One plot per day, four hours later each consecutive day. Plus three days per month, separated by a day, with 6 plots (*i.e.* at four hourly intervals). See the figure below.

45 - 46 plots per month (545 per year) would extend the collar life to 2.5 - 3 years (expected lifespan *ca.* 1 500 data points) – this is double that expected with the current 3 plots per day (1 095 per year).

By allowing the animals to go through more that one full daily behavioural cycle (feeding, resting, drinking etc during particular periods during the day), the time interval of 28 hrs between consecutive data points would reduce the danger of autocorrelation between data points when calculating daily range use.

To examine within day patterns in habitat selection, the schedule would provide 7 – 8 location points for each time of per month, each at least two days apart.

Three days per month of plots every 4 hours would allow movement patterns within the day to be evaluated at a finer temporal scale than is possible with the 8-hourly intervals currently being used. Four hourly intervals may have more biologically meaningful than 8-hourly intervals in that behaviour and habitat selection at this temporal scale are based on the environmental parameters measurable it spatial scales appropriate to this study (*e.g.* topography, distance to water, forage quality and quantity - Bailey, D.W., Gross, J.E., Laca, E.A., Rittenhouse, L.R., Coughenour, M.B., Swift, D.M. & Sims, P.L. 1996. Mechanisms that result in large herbivore grazing distribution patterns. *Journal of Range Management* **49**:386-400).

Sampling intensively (*i.e.* every 4 hours) around the middle of the month would facilitate the evaluation of these data on a monthly basis (e.g. ease comparison with mean monthly rainfall data).

Separating the three days of intensive sampling by a day would improve their statistical independence and allow the data to be averaged over the month (or season).

The 3 x 4-hourly sample sets per month would also allow the other 4 – 5 plots recorded at the same time of day during the month to be put into within the day (intra-diel) context.

It is proposed that location data be recorded at times that may be interpreted in terms of behavioural patterns and climatic conditions
02h00 – late night foraging/resting;
06h00 – dawn, cold time of day;
10h00 – midmorning, foraging, drinking;
14h00 – hottest time of the day, resting;
18h00 – evening, foraging;
22h00 – early night, foraging.

These behavioural and diel weather patterns will have to be corroborated with data and behavioural study in the field. This timetable will also avoid the confusion associated with collecting data at the interface between days (*e.g.* it is expected that data set to be recorded at 00h00 may in reality be recorded at 23h45 the day before or 00h15 the day following).

The greatest concern is that with an eccentric sampling strategy such as this, if one collar misses a signal one day it may put that collar out of synch with the other collars. From that day onward the location of that animal would be recorded 4 hours later than all the others and the comparison of location data between individuals would be compromised.

Also we need to know if the one plot per day (28 hr interval) can be programmed to run in an ongoing cycle (regardless of date), while the intensive sampling (4 hr interval) can be programmed to run each month on the 13^{th}, 15^{th} and 17^{th} day of that month.

Steve Henley
6 Nov 2004

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
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2						x																		
3										x														
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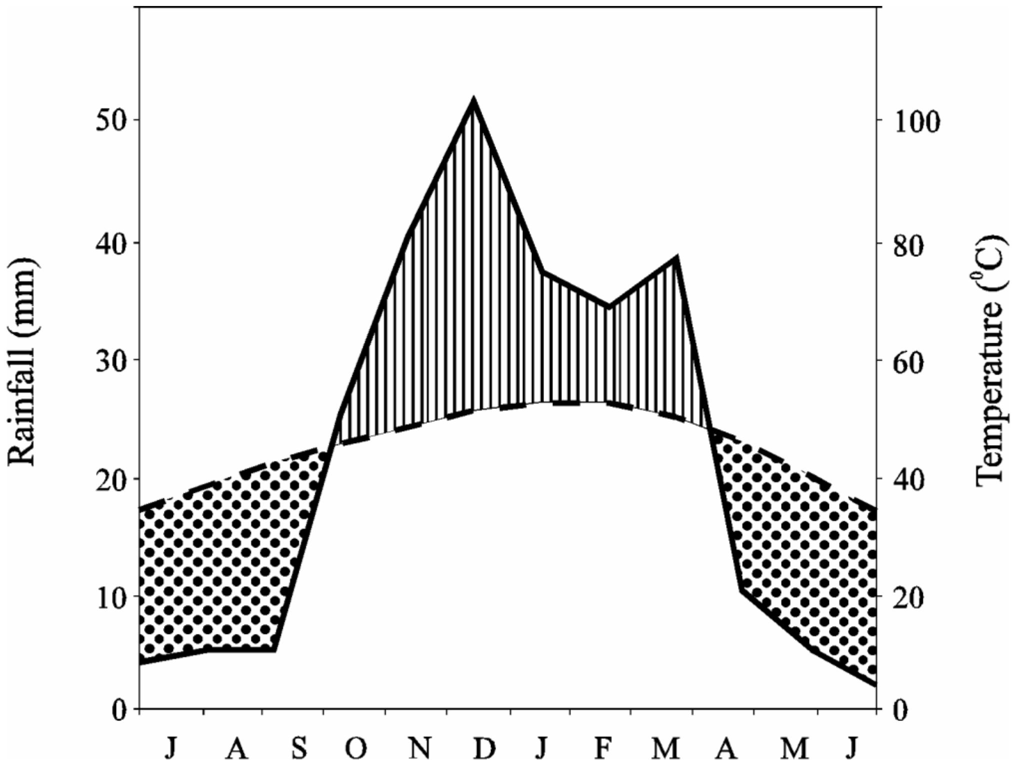
Proposed GPS-telemetry sampling schedule. Rows represent days of the month, and columns times of the day.

Appendix 2

Climatic seasons defined

Long-term rainfall data from the Kruger NP suggest that this region is subject to an 18 year quasi-rainfall cycle. Nine years with rainfall typically above the long-term annual average and nine years of typically below average rainfall (Gertenbach 1980). Consequently, the definition of seasons was based on data from weather stations in and around the APNR that span a period of 20 years or more. These were Ingwelala (1983 – 2004), Hoedspruit (1977 - 2004) and Kingfisherspruit, KNP (1957 – 2003).



A simplified composite climate diagram based on mean monthly rainfall and median daily temperature data from the Hoedspruit weather station. The solid line represents mean monthly rainfall and the dashed line median daily temperature. The stippled area is the arid period (dry season) and the lined area the humid period (wet season).

The aim is to derive an objective definition of ecologically meaningful seasons. Current conditions do not exist in isolation, and as such consideration is given to the influence of the preceding months conditions. Furthermore, it is to be expected that there is a substantial amount of spatial variation in conditions such as rainfall and as such is based on change in relative conditions (%). Nonetheless, absolute values provide a useful benchmark against which present conditions may be compared (*e.g.* a general rule of thumb amongst rangeland scientists is that 15-20mm is the minimum amount of rain required to fall during a single event to initiate grass growth in the early wet season) and so the absolute amount of rainfall is also considered.

Dry season: May → September

- Mean monthly rainfall is <5% (typically <2%) of the mean annual total.
- Each month receives ≤10 mm of rain (September in the Kingfisherspruit area is an exception).
- The first month of this season receives <½ (typically ⅓) the rainfall of the preceding month's mean.
- The total seasonal rainfall accounts for <10% of mean annual total.

Dry-wet transitional period: October

- Mean monthly rainfall is 5-10% of the mean annual total.
- Each month receives ≤25 mm of rain.
- At least one rainfall event totalling ≥15mm.
- The total monthly rainfall is a substantial increase (>2x, typically 3-4x) over the preceding month's mean.

Wet Season: November → March

- Mean monthly rainfall is ≥10% of the mean annual total.
- Each month receives ≥50mm of rain. Monthly rainfall may decrease towards the end of the season (>40mm), however due to the preceding month's high rainfall soil moisture remains relatively high.
- The total seasonal rainfall accounts for >75% of mean annual total.

Wet-dry transition period: April

- Mean monthly rainfall is ≤10% of the mean annual total.
- Each month receives ≤50 mm of rain.
- The total monthly rainfall is a substantial decrease (≤½) over that of the preceding month.